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2 pages of claims, 7 pages of description and 0 page of drawings contained in the Chinese Publication

[54] **Title:** A Method for Manufacturing Plant Fiber Cement Composite Board Using Hot-pressing

[57]**Abstract:** The invention, which belongs to the building material field, relates to the improvement of the method for manufacturing plant fiber cement composite board using hot-pressing. According to the invention, other materials such as calcium carbonate or sodium bicarbonate, soluble glass, sodium fluosilicate, and etc. are added into the raw materials for board manufacturing as described in Chinese Patent No. 92104346.5. The said board manufacturing materials are stirred and mixed for three times, and then applied by other techniques such as hot-pressing board manufacturing and humidifying treatment to produce the plant fiber cement composite board in short period using the common hot presser for artificial board. The pressing time is shortened from 6-8 hours to about 10 minutes. This results in a cut-down of the investment on equipments, a reduction of the production cost and an improvement of the quality of products.

Claims:

1. A method of manufacturing plant fiber cement composite board using hot-pressing, in which the plant fiber is used as the reinforcing material and cement, particularly the silicate cement used as the binder, the method includes the mechanical crushing and screening of the plant materials, as well as the pavement, hot-pressing and post-treatment of the mixed board manufacturing materials, characterized in that,

(1) Ingredients and dosages of the board manufacturing materials:

A. plant fiber, which is 15-30% of the finished plant fiber board by bone dry weight;

B. water, which is 20-40% of the bone dry weight of the finished plant fiber board ;

C. calcium oxide or calcium hydroxide, which is 4-10% of the bone dry weight of the finished plant fiber board;

D. calcium chloride or magnesium chloride, which is 30-60% of calcium oxide or calcium hydroxide added by weight;

E. calcium carbonate or sodium bicarbonate, which is 7-13% of the bone dry weight of the finished plant fiber board ;

F. soluble glass, which is 4-10% of the bone dry weight of the finished plant fiber board;

G. sodium fluosilicate, which is 10-15% of soluble glass by weight;

H. cement, which is 50-66% of the bone dry weight of the finished plant fiber board;

(2) the mixture of board manufacturing materials, which is completed by stirring 3 times, wherein, for the first stirring, plant fiber, water, calcium oxide or calcium hydroxide, calcium chloride or magnesium chloride, calcium carbonate or sodium bicarbonate, sodium fluosilicate are added into the agitator and stirred for a certain period of time; at the second stirring time, the soluble glass is added and stirred for a certain period of time again, and the third stirring is initiated after the plant fiber is homogeneously covered with the produced viscous liquid; and prior to the third stirring, appropriate amount of cement is added which, after the third stirring, will mingle homogeneously with the mixture resulted from the previous two stirrings;

(3) process parameters for hot pressing as follows:

the temperature for hot pressing, which is 90-125℃;

the pressure, which is 2.0-3.5 Mpa;

the time for hot pressing, which is determined by the empirical formula:

$$T = 160(t-80)^{-1} + \mu[a^{-1} + (\beta+\gamma)^{-1}] + 0.5(\delta+\eta-29) + \xi,$$

in which,

T stands for hot pressing time in terms of minutes;

t stands for the temperature of the hot pressing board, the value of which is between 90-125 ℃;

μ stands for the adjustment coefficient of the plant fiber varieties, the value of which is between 21-30 in terms of minutes;

a stands for the percentage of calcium carbonate or sodium bicarbonate in the bone dry weight of the finished board, which is dimensionless;

β stands for the percentage of calcium chloride or magnesium chloride in the bone dry weight of the finished board, which is dimensionless;

γ stands for the percentage of calcium oxide or calcium hydroxide in the bone dry weight of the finished board, which is dimensionless;

δ stands for the percentage of water added in the bone dry weight of the finished board, which is dimensionless;

η stands for the percentage of the calculated gross weight of water in the bone dry weight of the finished board, with the plant fiber moisture content taken into consideration, which is dimensionless;

ξ stands for the adjustment coefficient of the board thickness in terms of minutes, and when the thickness of the finished board is 4-8 mm, ξ should be -1; when the thickness of the finished board is 9-18 mm, ξ should be 9 less than the numerical value (millimeter) of the actual thickness of the finished board; when the thickness of the finished board is 19-30 mm, ξ should be 10.

(4) post-treatment procedures such as edge sawing and maintenance at room temperature, are performed after the hot pressed plant fiber cement composite

board is humidified for 5-7 days in the environment in which the temperature is between 15-30℃ and the relative humidity is between 50-70%.

2. The method of manufacturing plant fiber cement composite board using hot-pressing according to claim 1, characterized in that the adopted plant fiber materials can be annual or perennial plant materials wherein the annual includes hemp stalk, cotton stalk, corn stalk (corncob), sunflower stalk (head, shell), tobacco stalk, wheat straw, reed, thatch grass stalk, bagasse, pachyrhizus ratan, haulm (shell), peanut shell, hards, grain stalk, grain sorghum stalk, bean stalk, ceiba scraps and cocoanut shell; and, the perennial plant includes arbor, frutex, branch and twig materials, bamboo, and the processing residues of the above plants.

3. The method of manufacturing plant fiber cement composite board using hot-pressing according to claim 1 or 2, characterized in that the first stirring lasts 3-7 minutes, the second 2-6 minutes and the third 4-6 minutes.

4. The method of manufacturing plant fiber cement composite board using hot-pressing according to claim 3, characterized in that, in paving the mixed board manufacturing materials into board blank, fiberglass or its fabrics, cotton-linen fiber or its fabrics, non-woven fabrics, metal gauze, sheet metal, tinsel, fine reinforcing steel, and etc. can be added onto the upper- and under-surface of the board blank and/or added into the middle of the board blank before the commencement of hot pressing.

Description

A Method of Manufacturing Plant Fiber Cement Composite Board Using Hot-pressing

The invention, which belongs to the building material field, relates to the improvement of the method for manufacturing plant fiber cement composite board.

The plant fiber-reinforced cement composite board is a kind of excellent material for architecture, decoration and furniture-manufacturing, which is listed as a material for prior popularization by the Construction Department in China. The Chinese Patent No. CN92104363.5 disclosed a method of manufacturing cement composite board using plant fiber, especially, annual plant fiber, with relatively high content of anti-coagulating substances. That patent adopted a new means in dealing with the anti-coagulation action of the plant fiber extracts, i.e. managing to separate plant fiber from cement, which greatly reduces the extracts so that they are not likely to interfere with the curing of the cement. When the plant fiber is mixed and stirred with calcium oxide, calcium chloride and water, calcium oxide and calcium chloride will produce a viscous liquid containing calcium oxychloride, which will soak and cover the plant fiber to jam the cell's pores of the plant fiber, and at the same time prevent the anti-coagulating substances in the fiber from being separated out and reduce their activity. When thus treated plant fiber is mixed with the cement, the plant fiber cannot directly contact with the alkaline solution. Thereby, the amount of starch, hemicellulose and etc. hydrolyzed into sugar can be considerably reduced so that the anti coagulating action is suppressed. This method is effective in industrialized production of cement composite board using plant fiber with a relatively high content of extracts. But this method usually employs cold pressing. Its disadvantage is that the board blank must be retained in the mould, i.e. in the state of mould-locking, when being sent into the drying house to facilitate its setting, and cannot be demoulded until the board blank is strong enough, because the cement needs 6-8 hours to set after being pressed into mould. This way of board manufacturing needs to use the mould for a long period, so it is called long period method. In the long period method of manufacturing, large numbers of mould-locking clamps, pads and tunnel kilns are needed,

which requires great investment, and increases the production costs and difficulties. Moreover, there is a comparatively larger deviation in the thickness of the board thus produced ,and thinner board cannot be produced in this way. That patent also mentioned a way of hot pressing with some adhesives added for the production of thinner board. In this way, the minimum thickness of the board produced can be 6 mm. However, this method also requires mould-locking after pressing, and demoulding after the board blank being dried together with the mould in the drying house. It is still a long period method. So it also has the disadvantages of long setting time, huge investment, and high production cost.

In the recent decade, there appeared a hot-pressing method abroad, or called as short period method, which shortens the setting time of cement to about ten minutes. It not only saves a lot of clamps for mould-locking, but it also ensures the homogeneity of the board. There have been factories adopting this technical method in Finland and Hungary. However, this technique requires special hot pressers and moulds. When being pressed, the board blank must be deflated into approximate vacuum, and then CO_2 gas is let in. The quality of the board is determined by the vacuum degree inside the board blank, the homogeneity of the CO_2 gas distributed inside the board blank, the tightness of the hot presser, and the absorbability of the CO_2 gas by the board blank, etc.. Not only is the hot pressers costly, but also the exhaust of the CO_2 gas will cause environmental pollution. Because of the above disadvantages, the technique hasn't been popularized until now. In our country, only some colleges or universities did researches on the technique in their laboratories.

This invention aims at providing a method of manufacturing plant fiber cement composite board using hot-pressing, which does not require the deflating of the board blank into vacuum or the letting in of CO_2 gas. With the common hot pressers, the setting time for the cement in the pressed plant fiber cement composite board can be reduced to about 10 minutes. Therefore, the investment of the factory construction and production cost can be reduced too. Also, board as thin as 4 mm can be pressed and the homogeneity of the board thickness can be ensured.

The technical solution of the invention is the following. The method of manufacturing plant fiber cement composite board using hot-pressing adopts the plant

fiber as the reinforcing material, and cement, particularly the silicate cement as the binder. The processing steps include the mechanical cracking and screening separation of the plant materials, together with the pavement, hot-pressing and post-treatment of the mixed board manufacturing materials. It is characterized in that:

(1) Ingredients and dosage of the board manufacturing materials:

A. plant fiber, which is 15-30% of the finished plant fiber board by bone dry weight;

B. water, which is 20-40% of the bone dry weight of the finished plant fiber board;

C. calcium oxide or calcium hydroxide, which is 4-10% of the bone dry weight of the finished plant fiber board;

D. calcium chloride or magnesium chloride, which is 30-60% of calcium oxide or calcium hydroxide added by weight;

E. calcium carbonate or sodium bicarbonate, which is 7-13% of the bone dry weight of the finished plant fiber board;

F. soluble glass, which is 4-10% of the bone dry weight of the finished plant fiber board;

G. sodium fluosilicate, which is 10-15% of soluble glass by weight;

H. cement, which is 50-66% of the bone dry weight of the finished plant fiber board;

(2) the mixture of board manufacturing materials, which is completed by stirring 3 times, wherein, for the first stirring, plant fiber, water, calcium oxide or calcium hydroxide, calcium chloride or magnesium chloride, calcium carbonate or sodium bicarbonate, sodium fluosilicate are added into the agitator and stirred for a certain period of time; at the second time, the soluble glass is added and stirred for a certain period of time again, and the third stirring is initiated after the plant fiber is homogeneously covered with the produced viscous liquid; and, before the third stirring, appropriate amount of cement is added which, after the third stirring, will mingle homogeneously with the mixture obtained from the previous two stirrings;

(3) process parameters for hot pressing as follows:

the temperature for hot pressing which is 90-125 ℃;

the pressure which is 2.0-3.5 Mpa;

the time for hot pressing which is determined by the empirical formula:

$$T = 160(t-80)^{-1} + \mu[a^{-1} + (\beta+\gamma)^{-1}] + 0.5(\delta+\eta-29) + \xi,$$

in which,

T stands for hot pressing time in terms of minutes;

t stands for the temperature of the hot pressing board, the value of which is between 90-125 ℃;

μ stands for the adjustment coefficient of the plant fiber varieties, the value of which is between 21-30 in terms of minutes;

a stands for the percentage of calcium carbonate or sodium bicarbonate in the bone dry weight of the finished board, which is dimensionless;

β stands for the percentage of calcium chloride or magnesium chloride in the bone dry weight of the finished board, which is dimensionless;

γ stands for the percentage of calcium oxide or calcium hydroxide in the bone dry weight of the finished board, which is dimensionless;

δ stands for the percentage of water added in the bone dry weight of the finished board, which is dimensionless;

η stands for the percentage of the calculated gross weight of water in the bone dry weight of the finished board, with the plant fiber moisture content taken into consideration, which is dimensionless;

ξ stands for the adjustment coefficient of the board thickness in terms of minutes, and when the thickness of the finished board is 4-8 mm, ξ should be -1; when the thickness of the finished board is 9-18 mm, ξ should be 9 less than the numerical value (millimeter) of the actual thickness of the finished board; when the thickness of the finished board is 19-30 mm, ξ should be 10.

(4) post-treatment procedures such as edge sawing and maintenance at room temperature, are performed after the hot pressed plant fiber cement composite board is humidified for 5-7 days in the environment in which the temperature is between 15-30 ℃ and the relative humidity is between 50-70%.

The advantages of the invention are that it greatly reduces the setting time of the cement composite board so that a great number of moulds, clamps, pads and kilns are decreased, huge investment is saved, the production process is shortened, the production cost is reduced and the quality of product is improved. Compared with the hot pressing method abroad, this invention can help to save lots of investment on the equipments, to simplify the production process, to prevent environmental pollution and to reduce production cost with the quality of the product being ensured.

The following are detailed specification of this invention. Both the annual and perennial plant can be used as plant fiber for board manufacturing. The annual includes hemp stalk, cotton stalk, corn stalk (corncob), sunflower stalk (head, shell), tobacco stalk, wheat straw, reed, thatch grass stalk, bagasse, pachyrhizus ratan, haulm (shell), peanut shell, hards, grain stalk, grain sorghum stalk, bean stalk, ceiba scraps and cocoanut shell. The perennial plant includes arbor, frutex, branch and twig materials, bamboo, and the processing residues of the above plants. As for the processing steps like crushing, screening, paving and post-treatment, etc., the present invention adopts the substantially same method as that in Chinese Patent No. CN 92104363.5, for example, the adoption of "covering theory" to settle the anti-coagulating action of the plant fiber extracts on the cement. When the plant fiber is mixed with calcium oxide, calcium chloride and water, a kind of viscous liquid produced by aqueous solutions of calcium oxide and calcium chloride will soak and cover the plant fiber and jam the cells and pores of the plant fiber so that the anti-coagulating substances in the fiber can be prevented from being separating out and their activity will be reduced. In this way, the anti-coagulation action of the plant fiber is suppressed. Here, the same processing steps and the mechanism of suppressing the anti-coagulating action of plant fiber as stated above will not be explained again.

The creativity of the invention mainly lies in that it provides a solution to the problem of how to shorten the setting time of cement in the pressing of the plant fiber concrete composite board. There are three technical keys in settling the problem: the first is the optimization of the compositions of the materials for board manufacturing; the second is the timing for hot pressing; the third is the humidification after hot pressing.

The first technical key is the addition of new components into the materials for

board manufacturing. First, add calcium carbonate or sodium bicarbonate of proper amount into the board manufacturing materials and mix and stir them homogeneously in the first stirring, the weight of which is 7-13% of the bone dry weight of the finished plant fiber board. Then, add soluble glass and sodium fluosilicate of proper amount into the board manufacturing materials. Soluble glass cannot be added in the first mixing because soluble glass immediately reacts and agglomerates when mixed with aqueous solutions of calcium chloride. Therefore soluble glass should be added in the second stirring alone and the cement in the third. Consequently, the mixing of the board manufacturing materials comprises three stirrings. The first stirring lasts 3-7 minutes, the second lasts 2-6 minutes and the third 4-6 minutes. Sodium fluosilicate is the hardener of the soluble glass, which accelerates the coagulation of the soluble glass. It can be added in the first stirring together with other materials. The function of the newly added components lies in that when the board blank is hot-pressed, calcium carbonate or sodium bicarbonate in the mixture will be pyrolyzed and produce lots of CO_2 gas, which can fully and homogeneously contact with cement in the board manufacturing materials because calcium carbonate or sodium bicarbonate has been mixed homogeneously with the other board manufacturing materials. The CO_2 gas accelerates the setting of the cement due to its charring effect. At the same time, the sodium fluosilicate helps to solidify the soluble glass added and further improves the preliminary strength of the board blank. In this way, the strength of the board blank can soon reach the requirement and the short period production can be realized.

The second technical key is accurate timing for hot pressing. In the short period production, time for hot pressing is one of the critical factors affecting the quality of the product. If hot pressed for too long a time, the cement of the board blank will be dried and difficult to hydrate again so that the board blank lacks strength. If hot pressed for too short a time, the board blank will not obtain the required strength and it cannot be demoulded and unloaded. There are many factors which have effects on the timing for hot pressing. Based on experiments, the following empirical formula can be adopted to calculate the proper time for hot pressing.

$$T = 160(t-80)^{-1} + \mu[a^{-1} + (\beta+\gamma)^{-1}] + 0.5(\delta+\eta-29) + \xi,$$

in which, T stands for the temperature for hot pressing, which uses minute as unit; t

stands for the average temperature of the upper and lower hot pressing board, the value of which is between 90-125 ℃; μ stands for the adjustment coefficient of the plant fiber variety, which uses minute as unit and its value is between 21-30; a stands for the percentage of the weight of calcium carbonate or sodium bicarbonate in the bone dry weight of the finished board, which is dimensionless; β stands for the percentage of the weight of calcium chloride or magnesium chloride in the bone dry weight of the finished board, which is dimensionless; γ stands for the percentage of the weight of calcium oxide or calcium hydroxide in the bone dry weight of the finished board, which is dimensionless; δ stands for the percentage of the weight of water added in the bone dry weight of the finished board, which is dimensionless; η stands for the percentage of the calculated gross weight of water, with the plant fiber moisture content taken into consideration, in the bone dry weight of the finished board, which is dimensionless; ξ stands for the adjustment coefficient of the board thickness, which uses minute as unit. When the thickness of the finished board is 4-8 mm, ξ should be -1; when the thickness of the finished board is 9-18 mm, ξ should be 9 less than the numerical value in millimeter of the actual thickness of the finished board; when the thickness of the finished board is 19-30 mm, ξ should be 10. The thickness between 19-30 mm is called as special thickness. In the pressing of board of such thickness, because the board blank is very thick, the hot pressing time might be prolonged up to about 30 minutes if the hot pressing temperature is at its lower limitation. The following table shows calculated time for hot pressing in 8 examples. The serial numbers of the examples in this table is applicable to other tables herein. For instance, example 1 in each table refers to the first example, and so on.

Table 1 The calculation table for hot pressing timing

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8
T	12	11	12	9	12	20	7.5	33
t	120	118	120	115	120	100	125	90
μ	30	21	30	26	29	22	22	30
a	9.2	6.7	11.2	13	11.4	9.45	9	9.4
β	6.6	5	5.8	6.6	5.8	6.7	3.5	6
γ	7.2	6.8	8	9.5	8.1	7.6	6.3	7
δ	29	29	30	31.4	29.2	27	28	29
η	3	1	2	1	3	1	1	3
ξ	1	1	1	-1	1	9	-1	10

In hot pressing, the common hot presser for the manufacturing of artificial board can be employed. The temperature for hot pressing is between 90-125 ℃ while the pressure is between 2.0-3.5 Mpa.

The third technical key is the humidification immediately after hot pressing. The hot-pressed plant fiber cement composite board is put into the environment for 5-7 days in which the temperature is between 15-30 ℃ and the relative humidity is between 50-70%. During the about 10 minutes for hot pressing, though the cement in the board blank has reached the preliminary strength required for demoulding, transportation and edge sawing, it has not hydrated and hardened sufficiently. In order to improve the resulting strength of the board, the cement must hydrate sufficiently. The humidification is just for this purpose.

Due to the adoption of the three technical keys above, the present invention can manufacture plant fiber cement composite board by the short period method with common hot presser such as the equipment useful in the production of flakeboard and fiberboard. Some of the out-of-dated chipboard producing equipment with some modification can also be used to manufacture eligible plant fiber cement composite board so that investment on equipment is considerably saved and the production cost is reduced.

In order to further improve the performance of the board, while the mixed board manufacturing materials are paved into board blank, reinforcing materials such as fiberglass or its fabrics, cotton and hemp fiber or its fabrics, non-woven fabrics, metal gauze, sheet metal, tinsel, fine reinforcing steel, and etc. can be added onto the upper- and under-surface of the board blank and/or added into the middle of the board blank. And the hot pressing is then started.

Example 1.

Ingredients:	common silicate cement	1.7 kg,
	crushed haulm	0.5 kg,
	calcium chloride	0.2 kg,
	powder of calcium oxide	0.22 kg,
	powder of calcium carbonate	0.28 kg,

soluble glass	0.12 kg,
sodium fluosilicate	0.02 kg
water	0.9 kg

Operation procedures:

Firstly, haulm, powder of calcium oxide, powder of calcium carbonate, sodium fluosilicate, calcium chloride and water are put into the stirring mill and stirred for 5 minutes. Then soluble glass is added and stirred for 3 minutes again. After that, cement is added and stirred for another 5 minutes. The mixture is taken out from the stirring mill and paved on the A3 steel plate coated with used machine oil. The board blank, the size of which is $48\times48\times3$ cm, is sent into the hot presser for 12-minute hot pressing with a pressure of 3.3 Mpa at the temperature of 120 ℃. The pressed board of 10 mm thickness is then taken out for immediate test. The tested preliminary strength of the board is 2.5 Mpa. Then the board is put into the humidification chamber at a temperature of 20 ℃ and relative air humidity of 65%. 7 days later, the board is taken out for edge sawing. After that, the board is placed under the room temperature for 28 days piror to another test. The tested density of the board is 1.31 g/cm^3, the water content is 12%, the plane tensile strength is 0.41 Mpa, the static bending strength is 9.6 Mpa. And, after the board has been immersed in water for 24 hours, the thickness expansion ratio of water absorption is 2%.

Because the operation procedures of all the examples are the same, the ingredients and parameters of hot pressing and data of performance of the other examples are listed in the following tables.

Table 2 Table of ingredients of examples 2-8, with the weight unit of kilogram

	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8
plant	wood branches and twigs	cornstalk	Fine hemp villus	cotton stalk	hemp stalk	bamboo filament	reed
weight of plant fiber	0.58	0.5	0.28	0.58	0.65	0.28	1.34
variety of cement	slag	silicate	silicate	silicate	silicate	silicate	slag
weight of cement	1.6	1.7	0.9	1.6	2.9	0.82	4.1

$CaCl_2$	0.15	0.18	0.09	0.18	——	0.05	——
$MgCl_2$	——	——	——	——	0.32	——	0.45
CaO	——	0.25	0.13	0.25	——	0.09	——
$Ca(OH)_2$	0. 2	——	——	——	0.36	——	0.52
$CaCO_3$	——	0.35	0.18	0.35	——	0.13	0.70
$NaHCO_3$	0.28	——	——	——	0.45	——	——
soluble glass	0.12	0.12	0.08	0.12	0.07	0.06	0.30
sodium fluosilicate	0.02	0.02	0.01	0.02	0.01	0.007	0.05
water	0.86	0.94	0.43	0.9	1.3	0.40	2.16

Table 3 Table of the process parameters and the performance of examples 2-8

	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8
The first mixing	5 minutes	5 minutes	4 minutes	5 minutes	6 minutes	3 minutes	7 minutes
The second mixing	3 minutes	3 minutes	2 minutes	3 minutes	5 minutes	2 minutes	6 minutes
The third mixing	5 minutes	4 minutes	3 minutes	4 minutes	6 minutes	3 minutes	6 minutes
Hot pressing temperature (℃)	118	120	115	120	100	125	90
Pressure (Mpa)	2.9	3.2	3.0	3.2	3.0	3.1	2.8
Time (minute)	11	12	9	12	20	7.5	33
humidifying Temperature (℃)	20	25	19	18	25	15	30
Humidifying humidity (%)	60	62	52	62	68	50	70
Humidifying time (day)	6	6	5	6	7	4	7
Density (g/cm^3)	1.28	1.36	1.37	1.35	1.15	1.56	1.2
Water content (%)	11.5	10.5	11.0	11.5	9.5	8	10.8
Anti-folding	13.5	9.6	14.8	12.2	8.5	16.2	8.9

strength (Mpa)							
Anti-tensile strength (Mpa)	0.40	0.45	0.60	0.41	0.36	—	0.37
expansion ratio (%)	2.1	1.8	1.2	1.9	2.4	1.2	1.8
Size of the finished product (cm)	48×48 × 1.0	48×48 × 1.0	45×45 × 0.6	48×48 × 1.0	48×48 × 1.8	48×48 × 0.4	48×48 × 2.7

* The anti-tensile strength refers to the plane anti-tensile strength.

* The expansion ratio is the thickness expansion ratio of water absorption after the board has been immersed in water for 24 hours.

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[54]发明名称 植物纤维水泥复合板热压生产方法

[57]摘要

本发明属于建筑材料领域，涉及对植物纤维水泥复合板生产方法的改进。本发明在中国专利92104346.5所述的制板原料的基础上，增加碳酸钙或者碳酸氢钠、水玻璃、氟硅酸钠等原材料，经过三次搅拌混合制板原料，经热压制板和增湿处理等技术措施，使用生产人造板材的普通热压机实现短周期生产植物纤维水泥复合板，使压制时间由6~8小时缩短到十几分钟。可大量节省设备投资，降低产品成本，提高产品质量。

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权　利　要　求　书

1、一种植物纤维水泥复合板热压生产方法，以植物纤维为增强材料，以水泥特别是硅酸盐水泥为粘合剂，其工艺步骤包括对植物原料的机械破碎和筛选工序，以及对混合好的制板原料进行铺装、热压和后处理，其特征在于，

（1）制板原料的成分和用量如下：

A、植物纤维，其绝干重量占制成的植物纤维成品板绝干重量的 15～30%；

B、加水量，是制成的植物纤维成品板绝干重量的 20～40%；

C、氧化钙或者氢氧化钙，占制成的植物纤维成品板绝干重量的 4～10%；

D、氯化钙或者氯化镁，占所加入氧化钙或者氢氧化钙重量的 30～60 %；

E、碳酸钙或者碳酸氢钠，占制成的植物纤维成品板绝干重量的 7～13%；

F、水玻璃，占制成的植物纤维成品板绝干重量的 4～10%；

G、氟硅酸钠，占水玻璃重量的 10～15%；

H、水泥，占制成的植物纤维成品板绝干重量的 50～66%；

（2）制板原料的混合通过三次搅拌完成，第一次搅拌时向搅拌机内加入植物纤维、水、氧化钙或者氢氧化钙、氯化钙或者氯化镁、碳酸钙或者碳酸氢钠、氟硅酸钠共同搅拌一定时间；第二次搅拌时加入水玻璃，再搅拌一定时间，待所生成的粘稠液体将植物纤维包裹均匀后，进行第三次搅拌；第三次搅拌前，加入适量水泥，经搅拌，与前两次搅拌的物料混合均匀；

（3）热压时的工艺参数如下：

热压温度为 90～125℃；

压力为 2.0～3.5MPa；

热压时间由下述经验公式确定：

$T=160(t-80)^{-1}+\mu[\alpha^{-1}+(\beta+\gamma)^{-1}]+0.5(\delta+\eta-29)+\xi$，式中，

T 为热压时间，以分钟为单位；

t 为热压板上温度，在 90～125℃之间取值；

μ 是植物纤维品种调节系数，在 21～30 之间取值，以分钟为单位；

α 是碳酸钙或者碳酸氢钠占成品板绝干重量的百分数，为无量纲；

β 是氯化钙或者氯化镁占成品板绝干重量的百分比，为无量纲；

γ是氧化钙或者氢氧化钙占成品板绝干重量的百分比，为无量纲；

δ是加入的水量占成品板绝干重量的百分比，为无量纲；

η是考虑了植物纤维含湿率以后计算出的总水量占成品板绝干重量的百分比，为无量纲；

ξ是板材厚度调节系数，以分钟为单位，成品板厚度为4～8毫米时，ξ取值为-1；成品板厚度为9～18毫米时，ξ取值为成品板实际厚度的毫米数减9；成品板厚度为19～30毫米时，ξ取值为10；

（4）将热压后的植物纤维水泥复合板放在温度为15～30℃、相对湿度为50～70%的环境中进行增湿处理5～7天之后，再进行锯边、常温养护等后处理工序。

2、根据权利要求1所述的植物纤维水泥复合板热压生产方法，其特征在于，所采用的植物纤维原料可以是一年生植物或者多年生植物原料，一年生植物包括：麻秆、棉秆、玉米秆（芯）、向日葵秆（盘、壳）、烟秆、麦秆、芦苇、茅草秆、甘蔗渣、地瓜秧、稻草（壳）、花生壳、麻屑、谷秆、高粱秆、豆秆、木棉屑、椰子壳；多年生植物包括乔木、灌木、枝杈材、竹子、以及上述植物的加工剩余物。

3、根据权利要求1或2所述的植物纤维水泥复合板热压生产方法，其特征在于，第一次搅拌的时间为3～7分钟，第二次搅拌的时间为2～6分钟，第三次搅拌的时间为4～6分钟。

4、根据权利要求3所述的植物纤维水泥复合板热压生产方法，其特征在于，在将混合好的制板原料铺装成板坯时，可以在板坯的上下表面覆盖和/或在板坯的中间加入玻璃纤维或其织物、棉麻纤维或其织物、无纺布、金属网、金属片、金属丝、细钢筋等，然后进行热压。

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说　　明　　书

植物纤维水泥复合板热压生产方法

本发明属于建筑材料制造领域，涉及对植物纤维水泥复合板生产方法的改进。

植物纤维水泥复合板是一种优良的建筑、装饰和家具制作材料，在中国已经被建设部列为重点推广的材料。中国专利 CN92104363.5 公开了一种适用于以阻凝物质含量较高的植物纤维特别是一年生植物的纤维制造水泥复合板的方法。该专利在解决植物纤维萃取物的阻凝作用这个问题时采用新的途径，即设法把植物纤维与水泥隔离开，使萃取物大大减少而且难以影响水泥的凝固。当把植物纤维与氧化钙、氯化钙以及水混合搅拌时，氧化钙与氯化钙会生成黏稠的包含氯氧化钙的液体，它们对植物纤维浸润包裹，堵塞了植物纤维的细胞孔腔，同时也使纤维中的阻凝成分难以析出并降低活性。经过这种处理的植物纤维再与水泥拌合时，植物纤维难以与碱性液体直接接触，因而大大减少了其中淀粉、半纤维素等水解成糖的数量，从而抑制了其阻凝作用的发挥。这种方法是使用含有萃取物数量较大的植物纤维，工业化生产水泥复合板的有效方法。但是这种方法一般采用冷压法，其缺点是：由于板坯压制成型后水泥需要 6～8 小时的凝固时间，因此需要将板坯留在模具中，即在锁模的状态下送入烘房促进其凝固，待板坯达到一定强度后才能脱模。这样生产的板材，使用模具的时间很长，称之为长周期。长周期法生产中需要大批的锁模夹具、垫板和隧道窑，投资大，增加了生产成本和难度。同时这种方法生产的板材厚度误差较大，也不能生产较薄的板材。该专利也提到一种在添加一些胶粘剂后进行热压的方法，这是为了生产较薄的板材而采取的措施，用此方法可以生产最薄 6 毫米的板材。但是这种热压方法仍然需要在压制后进行锁模，将板坯连同模具一起放入烘房烘干后才能脱模，仍然属于长周期，同样具有水泥硬化时间长、投资大、成本高的欠缺。

近十几年来，国外出现了一种热压法，又称短周期法，它将水泥硬化时间缩短到十几分钟，既省去大批锁模夹具，又能保证板材的厚度均匀。芬兰和匈牙利已经有使用该工艺方法的工厂。但是这种工艺必须使用特殊的热压机和模具，在压制板坯时必须将板坯内的空气抽出，近似真空，并向板坯内通入 CO_2 气体，板材的质量受板坯内的真空度、CO_2 气体在板坯内分布的均匀度、热压机的密封程度、CO_2 气体被板坯的吸收量等影响。不仅热压机造价高，

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而且 CO_2 气体逸出还会造成环境污染。由于存在上述缺点，该工艺至今未能推广。在我国，仅有某些高校在实验室对该工艺方法进行过研究。

本发明的目的是提供一种生产植物纤维水泥复合板的热压方法，不需要将板坯抽真空和通 CO_2 气体，使用普通热压机，就可将压制的植物纤维水泥复合板中的水泥硬化时间缩短到十几分钟左右，从而降低建厂投资和产品成本。同时能压制更薄的板材，最薄可达 4 毫米，并能保证产品的厚度均匀度。

本发明的技术方案是：一种植物纤维水泥复合板热压生产方法，以植物纤维为增强材料，以水泥特别是硅酸盐水泥为粘合剂，其工艺步骤包括对植物原料的机械破碎和筛选工序，以及对混合好的制板原料进行铺装、热压和后处理，其特征在于，

（1）制板原料的成分和用量如下：

A、植物纤维，其绝干重量占制成的植物纤维成品板绝干重量的 15～30%；

B、加水量，是制成的植物纤维成品板绝干重量的 20～40%；

C、氧化钙或者氢氧化钙，占制成的植物纤维成品板绝干重量的 4～10%；

D、氯化钙或者氯化镁，占所加入氧化钙或者氢氧化钙重量的 30～60 %；

E、碳酸钙或者碳酸氢钠，占制成的植物纤维成品板绝干重量的 7～13 %；

F、水玻璃，占制成的植物纤维成品板绝干重量的 4～10%；

G、氟硅酸钠，占水玻璃重量的 10～15%；

H、水泥，占制成的植物纤维成品板绝干重量的 50～66%；

（2）制板原料的混合通过三次搅拌完成，第一次搅拌时向搅拌机内加入植物纤维、水、氧化钙或者氢氧化钙、氯化钙或者氯化镁、碳酸钙或者碳酸氢钠、氟硅酸钠共同搅拌一定时间；第二次搅拌时加入水玻璃，再搅拌一定时间，待所生成的粘稠液体将植物纤维包裹均匀后，进行第三次搅拌：第三次搅拌前，加入适量水泥，经搅拌，与前两次搅拌的物料混合均匀；

（3）热压时的工艺参数如下：

热压温度为 90～125℃；

压力为 2.0～3.5MPa；

热压时间由下述经验公式确定：

$T = 160(t-80)^{-1} + \mu[\alpha^{-1} + (\beta+\gamma)^{-1}] + 0.5(\delta+\eta-29) + \xi$，式中，

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T 为热压时间，以分钟为单位；

t 为热压板上温度，在 90～125℃之间取值；

μ 是植物纤维品种调节系数，在 21～30 之间取值，以分钟为单位；

α 是碳酸钙或者碳酸氢钠占成品板绝干重量的百分数，为无量纲；

β 是氯化钙或者氯化镁占成品板绝干重量的百分比，为无量纲；

γ 是氧化钙或者氢氧化钙占成品板绝干重量的百分比，为无量纲；

δ 是加入的水量占成品板绝干重量的百分比，为无量纲；

η 是考虑了植物纤维含湿率以后计算出的总水量占成品板绝干重量的百分比，为无量纲；

ξ 是板材厚度调节系数，以分钟为单位，成品板厚度为 4～8 毫米时，ξ 取值为-1；成品板厚度为 9～18 毫米时，ξ 取值为成品板实际厚度的毫米数减 9；成品板厚度为 19～30 毫米时，ξ 取值为 10；

（4）将热压后的植物纤维水泥复合板放在温度为 15～30℃、相对湿度为 50～70%的环境中进行增湿处理 5～7 天之后，再进行锯边、常温养护等后处理工序。

本发明的优点是：比长周期法大大缩短了水泥复合板的硬化时间，从而节省了大量模具、夹具、垫板和窑炉，节约了投资，缩短了生产流程，降低了成本，提高了产品质量；与国外的热压方法相比，在保证产品质量的前提下，能节省大量的设备投资，简化生产过程，防止环境污染，降低产品成本。

下面对本发明方法做详细说明。本发明方法可以采用一年生植物或者多年生植物作为植物纤维原料制造板材，一年生植物包括：麻秆、棉秆、玉米秆（芯）、向日葵秆（盘、壳）、烟秆、麦秆、芦苇、茅草秆、甘蔗渣、地瓜秧、稻草（壳）、花生壳、麻屑、谷秆、高粱秆、豆秆、木棉屑、椰子壳；多年生植物包括乔木、灌木、枝杈材、竹子、以及上述植物的加工剩余物。在植物纤维的破碎、筛选、铺装、后处理等工艺步骤中，本发明采用了与 CN92104363.5 专利基本相同的方法，例如采用“包裹理论”解决植物纤维萃取物对水泥的阻凝问题。通过把植物纤维与氧化钙、氯化钙以及水混合搅拌，使氧化钙与氯化钙水溶液生成的黏稠液体，浸润包裹植物纤维，堵塞植物纤维的细胞孔腔，使植物纤维中的阻凝成分难以析出并降低活性，从而抑制植物纤维的阻凝作用。在此，对上述相同的工艺步骤和抑制植物纤维阻凝作用的机理不再赘述。

本发明的创造性主要在于解决了缩短植物纤维复合板压制过程中水泥凝

固时间的难题，解决此问题的要点是以下三个技术关键：一是优化制板原料的配方；二是掌握恰当的热压时间；三是热压后进行增湿处理。下面分别加以说明。

第一个技术关键是在制板原料中增加新成分，第一、在制板原料中加入适量的碳酸钙或者碳酸氢钠，与其他制板原料混合均匀，其用量是制成的植物纤维成品板绝干重量的 7～13%，在第一次搅拌时加入。第二、在制板原料中加入适量的水玻璃和氟硅酸钠，由于水玻璃和氯化钙水溶液混合时立即反应结块的原因，水玻璃不能在第一次搅拌时加入，必须在第二次搅拌时单独加入，而加入水泥则成为第三次搅拌，这样，使制板原料的混合变为三次搅拌的过程。第一次搅拌的时间为 3～7 分钟，第二次搅拌的时间为 2～6 分钟，第三次搅拌的时间为 4～6 分钟。氟硅酸钠是水玻璃的硬化剂，它可以加快水玻璃的凝固速度，它可以在第一次搅拌时随其他原料一起加入。增加的新成分的作用是，当板坯热压时，混合在原料中的碳酸钙或者碳酸氢钠受热分解，产生大量的 CO_2 气体。由于碳酸钙或者碳酸氢钠已经与其他制板原料混合均匀，使产生的 CO_2 气体能与制板原料中的水泥均匀的充分接触，由于 CO_2 气体对水泥的炭化作用，使水泥能够迅速凝固。同时，加入的水玻璃在氟硅酸钠的作用下也迅速凝固，进一步增加了板坯的初强度，使板坯很快达到满足脱模要求的强度，实现短周期生产。

第二个技术关键是准确掌握热压时间。在短周期生产中，热压时间的确定是影响产品质量的关键问题之一。热压时间过长，板坯内水泥中的水分被烤干，难以再进行水化，板材没强度；热压时间过短，板坯未达到初强度，不能脱模卸板。影响热压时间的因素很多，经实验，可以采用下面的经验公式计算出适当的热压时间：

$T = 160(t-80)^{-1} + \mu[\alpha^{-1} + (\beta+\gamma)^{-1}] + 0.5(\delta+\eta-29) + \xi$，式中，

T 为热压时间，以分钟为单位；t 为上下热压板上的平均温度，在 90～125 ℃之间取值；μ 是植物纤维品种调节系数，在 21～30 之间取值，以分钟为单位；α 是碳酸钙或者碳酸氢钠占成品板绝干重量的百分数，为无量纲；β 是氯化钙或者氯化镁占成品板绝干重量的百分比，为无量纲；γ 是氧化钙或者氢氧化钙占成品板绝干重量百分比，为无量纲；δ 是加入的水量占成品板绝干重量的百分比，为无量纲；η 是考虑了植物纤维含湿率以后计算出的总水量占成品板绝干重量的百分比，为无量纲；ξ 是板材厚度调节系数，以分钟为单位，当成品板厚度为 4～8 毫米时，取值为-1；成品板厚度为 9～18 毫米

时，取值为成品板实际厚度的毫米数减 9；成品板厚度为 19～30 毫米时，取值为 10。成品板厚度为 19～30 毫米时称为特种厚度，压制这类板材时，由于板坯很厚，当热压温度在低限时，热压时间可能延长，最长可达 30 分钟左右。下表给出 8 个实施例的热压时间计算实例，表中各实施例的编号对本文其他表格是通用的，例如各表中的例 1 都指实施例 1，其余类推。

表 1　热压时间计算表

	例 1	例 2	例 3	例 4	例 5	例 6	例 7	例 8
T	12	11	12	9	12	20	7.5	33
t	120	118	120	115	120	100	125	90
μ	30	21	30	26	29	22	22	30
α	9.2	6.7	11.2	13	11.4	9.45	9	9.4
β	6.6	5	5.8	6.6	5.8	6.7	3.5	6
γ	7.2	6.8	8	9.5	8.1	7.6	6.3	7
δ	29	29	30	31.4	29.2	27	28	29
η	3	1	2	1	3	1	1	3
ξ	1	1	1	-1	1	9	-1	10

热压时可以采用通用的生产人造板的热压机械，热压温度为 90～125℃，压力为 2.0～3.5Mpa。

第三个技术关键是热压后立即进行增湿处理。将热压后的植物纤维水泥复合板放在温度为 15～30℃、相对湿度为 50～70%的环境中堆放 5～7 天。由于在热压的十几分钟内，板坯内的水泥虽然能够达到脱模运输、锯边所要求的初强度，但是尚未充分水化和硬化。为提高板材的后期强度，必须使水泥有充分水化的过程。增湿处理就是为了达到这个目的。

由于本发明采用了上述三项技术关键，使用普通的热压机，例如生产刨花板和纤维板的设备，也能采用短周期法生产植物纤维复合板材。对于一些陈旧的刨花板生产设备，稍加改造，也能生产合格的植物纤维复合板，这就大大节省了设备投资，降低了产品成本。

为了进一步提高板材的性能，在将混合好的制板原料铺装成板坯时，可以在板坯的上下表面覆盖和/或在板坯的中间加入玻璃纤维或其织物、棉麻纤维或其织物、无纺布、金属网、金属片、金属丝、洗钢筋等加强材料，然后

进行热压。

实施例1。配料：普通硅酸盐水泥1.7公斤，经破碎的麦草秆0.5公斤，氯化钙0.2公斤，生石灰粉0.22公斤，碳酸钙粉0.28公斤，水玻璃0.12公斤，氟硅酸钠0.02公斤，水0.9公斤。操作步骤：先将麦草杆、生石灰粉、碳酸钙粉、氟硅酸钠、氯化钙和水放入搅拌机内搅拌5分钟，再加入水玻璃搅拌3分钟，再加入水泥搅拌5分钟，自搅拌机中排出，铺装在涂有废机油的A3钢板上，板坯尺寸为48×48×3厘米，送入热压机热压，压力3.3Mpa，温度120℃，热压时间12分钟，取出压制好的板子，厚度10毫米，立即进行测试，初强度为2.5MPa，放入温度为20℃，相对空气湿度为65%的增湿箱内，放置7天后取出锯边，再放在常温下28天后测试，板材密度1.31g/cm^3，含水率12%，平面抗拉强度0.41MPa，静曲强度9.6 MPa，浸泡24小时后吸水厚度膨胀率2%。

由于实施例的操作步骤相同，其他的实施例以列表的方式给出原料配方、热压参数和性能数据。

表2 实施例2～8原料配方表，重量单位为公斤。

	例2	例3	例4	例5	例6	例7	例8
植物品种	木枝杈	玉米秸	麻短绒	棉柴秆	麻秆	竹丝	芦苇
植纤重量	0.58	0.5	0.28	0.58	0.65	0.28	1.34
水泥品种	矿渣	硅酸盐	硅酸盐	硅酸盐	硅酸盐	硅酸盐	矿渣
水泥重量	1.6	1.7	0.9	1.6	2.9	0.82	4.1
$CaCl_2$	0.15	0.18	0.09	0.18	——	0.05	——
$MgCl_2$	——	——	——	——	0.32	——	0.45
CaO	——	0.25	0.13	0.25	——	0.09	——
$Ca(OH)_2$	0.2	——	——	——	0.36	——	0.52
$CaCO_3$	——	0.35	0.18	0.35	——	0.13	0.70
$NaHCO_3$	0.28	——	——	——	0.45	——	——
水玻璃	0.12	0.12	0.08	0.12	0.07	0.06	0.30
氟硅酸钠	0.02	0.02	0.01	0.02	0.01	0.007	0.05
水	0.86	0.94	0.43	0.9	1.3	0.40	2.16

表 3 实施例 2~8 工艺参数和性能表

	例 2	例 3	例 4	例 5	例 6	例 7	例 8
第一次搅拌	5 分钟	5 分钟	4 分钟	5 分钟	6 分钟	3 分钟	7 分钟
第二次搅拌	3 分钟	3 分钟	2 分钟	3 分钟	5 分钟	2 分钟	6 分钟
第三次搅拌	5 分钟	4 分钟	3 分钟	4 分钟	6 分钟	3 分钟	6 分钟
热压温度℃	118	120	115	120	100	125	90
压力 MPa	2.9	3.2	3.0	3.2	3.0	3.1	2.8
时间 分钟	11	12	9	12	20	7.5	33
增湿温度℃	20	25	19	18	25	15	30
增湿湿度 %	60	62	52	62.	68	50	70
增湿时间 天	6	6	5	6	7	4	7
密度 g/cm^3	1.28	1.36	1.37	1.35	1.15	1.56	1.2
含水率 %	11.5	10.5	11.0	11.5	9.5	8	10.8
抗折强度 MPa	13.5	9.6	14.8	12.2	8.5	16.2	8.9
抗拉强度* MPa	0.40	0.45	0.60	0.41	0.36	——	0.37
膨胀率* %	2.1	1.8	1.2	1.9	2.4	1.2	1.8
成品尺寸 cm	48×48 ×1.0	48×48 ×1.0	45×45 ×0.6	48×48 ×1.0	48×48 ×1.8	48×48 ×0.4	48×48 ×2.7

* 抗拉强度是平面抗拉强度。

* 膨胀率是水中浸泡 24 小时之后的吸水厚度膨胀率。